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A Major Natural Resource

Genetic vulnerability is a new and fancy way of describing an old problem. Every living thing is a product of its genotype and its environment. The genotype sets the potential for growth and development; the environment controls how much of the plant's potential will be realized.

Uniformity causes genetic vulnerability. The probability of an epidemic is increased when large numbers of plants are genetically alike; when one becomes susceptible, all become susceptible. In the case of the southern corn leaf blight, genetic diversity was sacrificed for greater corn productivity.

Three ingredients must coincide to produce a serious epidemic—a genetically uniform crop, a virulent pathogen, and a favorable environment. These three are known to plant breeders as a "disease triangle."

Because of uniformity, most U.S. crops are highly vulnerable. Uniformity does not invariably cause an epidemic, nor does genetic diversity guarantee one will not occur. Such species as live oaks and American elms have not been bred and distributed as crop varieties. Yet, their diversity does not protect them from diseases which are slowly killing them.

Powerful forces—the demands of producers and consumers—have created current crop uniformity. Plant breeders have only responded. Because no one wants to grow the second or third best crop variety, growers gravitate toward the best. We, as consumers, demand the best. Who could afford or freely elect to grow inferior varieties just to lower the probability of an unlikely epidemic?

Merely broadening the genetic base of our major varieties will not prevent epidemics. Germplasm is the key. The natural variability of germplasm existing within cultivated plant species and their wild relatives is a major natural resource. It must be preserved as a first line of defense.

Agricultural scientists must intensify collection and maintenance of foreign and domestic germplasm. We must be assured that this valuable genetic material is not lost. Once lost, it may never be recoverable. Some genetic material that looks worthless today may be invaluable tomorrow.

Genetic vulnerability can be minimized through a sound research program. By having pools of breeding lines with great genetic variety waiting in the wings, plant breeders can reduce the chances of an epidemic tragedy.—*M.M.M.*

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COVER: High above ARS test plots, a NASA airplane carrying thermal scanners takes the temperature of wheat. Comparisons between aerial thermal surveys and those on the ground will show whether aerial—and satellite—surveys are feasible (0476X406-3A). Article begins on page 7.

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This mechanical tree planter, and three laborers, can plant fruit trees eight times faster than conventional planting methods which require five people (0576R451–19A).

500 Trees Per Hour

A COLLECTION of good ideas about mechanical fruit tree planters has been brought together in one machine which, with a tractor and three people, has planted 500 trees per hour in early tests. The prevailing planting method takes five people all day to plant 500 trees.

Agricultural engineer Bernard R. Tennes (Agricultural Engineering Bldg., Michigan State University, East Lansing, MI 48823), recently tested the pilot machine in seven commercial orchards in southwestern Michigan.

"These preliminary trials were very encouraging," Dr. Tennes said. "In one case we planted 10 acres of tart cherry trees in 2 hours and 10 minutes.

"We took ideas from four different homemade tree planters already in use by fruit growers. Some of the existing machines did portions of the planting job well but didn't perform well over-all. By putting the best parts of all the machines together and improving them

a bit we now have a machine that does the entire job," he said.

The pilot machine opens a trench in either sod or cultivated ground, the tree is placed, then the unit closes the trench and compacts the soil around the tree. Only the placing of the tree is done by hand.

"Planting can be done at least eight times faster by this machine," Dr. Tennes said. "And the growers agree that the planter does a better job than could be done by hand planting. Of course we are still making improvements and adjustments."

Plant pathologist Clyde L. Burton will conduct follow-up evaluations of the trees every 6 months and thus check how the trees compare with others planted by conventional methods.

Dr. Tennes believes that the tree planter may have other limited uses such as installation of trickle irrigation and drainage lines.

Development of a mechanical planter is of importance now because of the massive replanting job facing Michigan fruit growers due to widespread damage caused by last winter's ice storm.—*R.G.P.*

The new tree planter opens a trench until the tree is placed, closes the trench, and then the angled wheels compress the soil around the tree (0576R450–8A).

A collection of good ideas in fruit tree planters was brought together in one machine by Dr. Burton, left, and Dr. Tennes. The pilot machine has planted 500 trees per hour in preliminary tests (0576R451–4A).

Workers look over nursery stock, then load it onto new tree planter as they make preparations for another planting run through the orchard (0576X450–20A).

Diagnosing Sick Soybeans

As a physician uses diagnostic instruments to interpret symptoms of disease, so do scientists require tools to study the effect of insect damage on yield.

The "patient": a soybean plant attacked by bollworms.

The goal: to determine at what stage of plant maturity the bollworms are feeding most heavily.

The system commonly used to study developmental stages of the soybean plant is primarily qualitative. Scientists now have a precise quantitative measure of pod growth applicable to the period from early pod elongation to full-size green beans.

Since pod thickness, which is a function of seed growth, is the only external pod dimension that increases after pods have attained full length, the lateral thickness of the pods was selected for measurement.

Research entomologists John M. McWilliams, J. H. Hatchett, and Earl A. Stadelbacher at the Bioenvironmental Insect Control Laboratory (P.O. Box 225, Stoneville, MS 38776), designed a hand caliper to provide a quick, reliable measurement of pod thickness.

The caliper is 15 centimeters (cm) long, 4 cm wide at the base, and 2.4 cm at the apex. It was constructed from three pieces of ⅛-inch aluminum; the angle of the V-slot is 70°10′, and the jaws are marked with gradations 4 millimeters (mm) apart that measure thickness in 0.5-mm increments.

The distance between gradations depends on the angle of the "V" selected and can be determined by trigonometry. A reference point for marking the calibrations, say the inventors, can be established with a round object of known diameter.

Soybeans of the Pickett 71 variety were planted and subsequently measured from August through October at Stoneville, Miss. At 3- to 7-day intervals all the pods on each of 12 plants were measured at the thickest point of the terminal bean by inserting this portion into the slot of the caliper. The long axis of the pod was kept perpendicular to the face of the caliper.

Researchers found that the increase in thickness was most rapid from September 9 to 25, when the pods were found to be filling rapidly.

Consecutive measurements may describe the growth of individual pods, but the average thickness of a representative sample of pods also provides a quantitative measure of overall pods at specific intervals.

In addition to research on bollworm feeding, the inexpensive new tool may also help determine the effect on yield of such stress factors as disease, low fertility, and moisture deficiency.

The research was cooperative with the Mississippi Agricultural and Forestry Experiment Station in Stoneville.—*P.L.G.*

Researcher employs newly-designed hand caliper to measure thickness of a soybean pod. Such measurements help determine stage of plant maturity at which bollworms feed most heavily, and the effects of various stresses on yields (PN–4121).

An Aphid Foiled

FARMERS and ranchers concerned with the destruction of alfalfa fields by the blue alfalfa aphid can expect some nonchemical relief by the fall of 1977 when the first aphid-resistant alfalfa variety is ready for planting.

Meantime, Federal and State scientists are continuing their development of more resistant varieties while searching the Orient for parasites of the fast-spreading insect.

ARS entomologists and University of California (UC) agronomists, along with interested farmers, have cooperated to come up with an alfalfa variety—dubbed CUF 101—that is nearly 53 percent resistant to the insect. Another variety, UC 102, is about 45 percent resistant. Both alfalfas are stopgap measures until lines are developed to give at least 90 percent aphid resistance.

ARS entomologist Mervin W. Nielson, Forage Insects Research Laboratory (2000 E. Allen Road, Tucson, AZ 85710), using alfalfa selections made by UC agronomist William F. Lehman, El Centro, Calif., says that CUF 101 will be ready with foundation seed by the fall of this year. Foundation seed is allotted to cooperating farmers who grow seed for seed producers, who in turn grow certified seed for planting as forage.

Dr. Lehman obtained aphid-resistant CUF 101 and UC 102 in field selections taken from a 20-acre alfalfa plot in the Imperial Valley of California.

"Plants appearing resistant to the aphid were examined closely for aphids, discoloration, misshapen leaves, and stunting. About 93 plants were saved from the 20-acre field and placed in a seed production cage where seed was produced during the summer of 1975," Dr. Lehman reported.

That seed is the seed from which Dr. Nielson made evaluations for resistance in greenhouse tests at Tucson while subjecting the alfalfa to heavy blue alfalfa aphid attack.

The blue alfalfa aphid was first discovered in the Imperial Valley of California and in Arizona in early 1975 and has since spread like wild-fire into Arizona, Nevada, Utah, all of California, into parts of Idaho and Oregon, and recently has been reported in New Mexico and Kansas.

Observers are fearful that it may continue to spread into other Midwestern States where it might find the environment more to its liking. The insect builds up high populations in the early part of the year, dies out when temperatures soar above 85° F, and then reappears in the fall during cooler weather. While the blue aphid is not spreading as fast as the spotted alfalfa aphid did in earlier times—that insect infested the entire country from the east to west coast in 1 year—it is moving fast, scientists report.

One factor that seems to aid its movement is a phenomenon observed by scientists that when populations reach a high level, the insect cycles to a winged adult and takes off for less infested areas.

Damage is caused by severe stunting of alfalfa plants and yellowing of the leaves from which plants have a hard time recovering. The insect sucks sap from the leaves and stems, preferring the terminals of the stems. Some scientists believe that the aphid also injects a toxin that is further damaging to the plant.

If no treatment is administered to fields when first infested in the spring, farmers can lose at least the valuable first cutting with the damage period extending over several months.

In the absence of aphid-resistant varieties, the only recourse farmers have is to spray. Fortunately, the insect is easy to kill with present-day insecticides already registered for alfalfa.

Agricultural economists are loath to put a price tag on the "new" aphid but considering the possible loss of the first cutting plus several insecticide applications at $5 to $7 per acre, it could amount to millions of dollars each year.

Alfalfa is this country's number one forage crop with an annual value (1975) of around $4 billion. Every 1 percent loss of yield, whether from insects, disease or other cause, means $40 million lost to farmers.

If the blue alfalfa aphid were to spread as fast and as wide as the spotted alfalfa aphid, and cause a minimal damage level of 5 percent, the total tab could amount to some $200 million, not including control cost.—*J.P.D.*

Dr. Ehrler inspects the condition of a head of wheat prior to evaluation for sap pressure in the "pressure bomb" (0476X403-36).

Sensing Soil Moisture—Remotely

LIKE PHYSICIANS taking temperature and blood pressure of human patients, agricultural scientists are taking the temperature and blood—sap—pressure of plants, looking for clues that will tell them under what soil moisture conditions the plants are growing.

When those clues are in, scientists believe they will be able to tell that "healthy" plants—those running temperatures near the "98.6" of normal plants—have adequate soil moisture and those running high temperatures have inadequate soil moisture. By knowing the water-use norm of each particular species of plant, whether wheat, corn, alfalfa, and so forth, the scientists will be able to tell the amount of soil moisture in the root zone of any particular crop.

So what?

Since plant temperatures can be taken by thermal infrared scanners—thermometers—from the ground, from aircraft, or from satellites, the findings could open up almost limitless possibilities for predicting major famines, pest outbreaks, and plant disease epidemics throughout the world.

The same knowledge could lead to development of information for the improvement of crop and rangeland management and prediction, and prevention of excessive soil erosion in areas of potential danger.

At the U.S. Water Conservation Laboratory (4331 E. Broadway Road, Phoenix, AZ 85040), physicists Ray D. Jackson and Sherwood B. Idso, soil scientist Robert J. Reginato, and plant physiologist William L. Ehrler are taking thousands of temperature and sap pressure readings on six plots of wheat kept at various stages of wetness. One plot is not irrigated—in Arizona that means it's very dry—one is irrigated slightly, another has a normal irrigation treatment, one is irrigated to exact consumptive use figures, another carries an excess of water, and the last is kept in an almost rice paddy stage.

Twice a day, in the heat of the afternoon and in the cool of the morning hours, thermal infrared temperatures—

Above: *Aboard a NASA airplane, John Millard, NASA researcher, and Robert Goettelman, NASA contract physicist, adjust the infrared scanner before making flights over the ARS test plots (0476X404–19).* Below: *Twice weekly, physical science technician John M. Pritchard measures wheat height in the test plots (0476X408–14A).*

Above: *Using an infrared radiation thermon eter, Dr. Reginato takes late afternoon pla temperatures (0476X405–5).* Right: *Scientis*

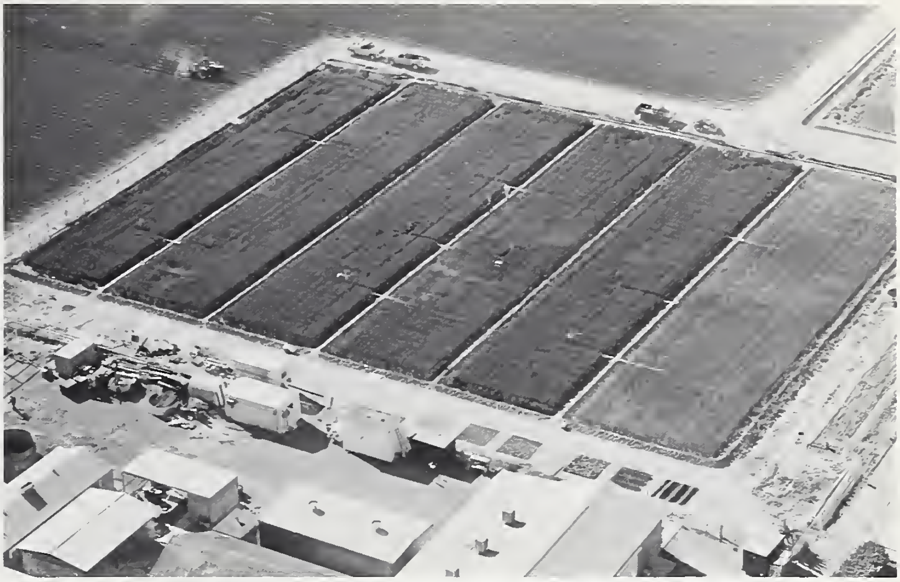
not to be confused with color infrared—are taken of plants in all the plots. At the same time with the use of a "pressure bomb," sap pressure readings are taken of plants from each of the plots.

Plants exert a suction in order to draw moisture from the soil. The less moisture, the more suction the plant must exert in order to supply itself with water. Under those conditions, the plant is under what scientists call "stress."

That stress or suction or sap pressure can be measured and related to the thermal infrared temperature of the plant.

When the study is further along, the scientists theorize they will be able to tell by the thermal temperature how much water is in the plant and therefore how much moisture is in the root zone.

In order to measure the suction, a plant is picked out of the ground, roots and all. When the stem is cut with a razor blade above the roots, suction inside the plant draws the sap up into the stem. If the plant is under severe stress, the sap is sucked far into the stem. If stress is minimal, the sap is sucked only a short distance up the stem. Those "clues" tell scientists the soil moisture conditions which exist at

e taking thousands of temperature and sap essure readings on these six instrument-udded test plots at the U.S. Water Conservation Laboratory in Phoenix, Arizona. The goal: prediction of tomorrow's crop yields. Such forecasting technology would be of inestimable value to mankind in the struggle to increase global food production (0476X401–29).

the time that the plant was picked.

To measure the suction, the plant is placed in the pressure bomb with an airtight seal placed around the stem near where it was cut. The open end of the stem is on the outside of the sealed "bomb" while all the rest of the plant is inside. Pressure in the form of nitrogen gas is applied to the external parts of the plant inside the bomb until the sap is forced back down the stem to the razor cut. By measuring the pressure needed to return the sap back to the stem cut, scientists are able to determine what suction the plant was exerting before it was pulled from the field.

The Phoenix scientists in earlier studies detected and estimated soil moisture in the top inch of bare soil with the use of portable thermal infrared thermometers held above the ground by hand or on ladders farther overhead. Occasionally, they had the use of thermal scanners in aircraft flown by the National Aeronautics and Space Administration (NASA) over the plots in Phoenix. Soon they hope to have like information coming from NASA satellites.

At the start of the bare soil study, thermal infrared temperatures of the soil were taken at the coolest part of the day—just prior to dawn—and again at the hottest—about 2 pm. The difference between the two readings gave the scientists a reading as to how much moisture there was in the soil. The lower the reading, the more water present.

Later it was found that one soil temperature reading—at the hottest part of the day—could be taken and related to the air temperature just above the soil or crop at the same time of day. The difference between the two temperatures was related to soil moisture content.

It was only natural that the study evolved from 1 inch of bare soil into studying the crop canopy in order to estimate soil moisture in the root zone several feet below the surface by diagnosing the "health" of the plants.

Much research is still to be done before parameters—values, "barometers"—can be published on the remote detection of soil moisture.

Meantime, the scientists have this to say:

"One of the many prime benefits of remote detection of soil moisture would be prediction of agricultural production. Forecasting is an activity of major economic importance, practiced in virtually all countries.

"Indeed, yearly governmental expenditures for forecasting are about $40 million for the United States and $100 million for the world. That investment is justified because precise foreknowledge of harvests allows governments to formulate domestic and foreign policies whose effects greatly transcend the monetary outlay. The yearly net loss in social well-being due to error in production forecast for the United States grain crops alone, for instance, is calculated to be about $300 million for each 1 percent error.

"Social returns of money invested in crop-forecasting research are comparable to the returns in such high payoff agricultural research as hybrid corn studies."—*J.P.D.*

Assistant plant pathologist Luka Cuk checks for insects on plants grown to determine male or female sterility as well as for seed supply (0176X56–15).

Crop with a future

Plant breeder Vida Nikolic-Vig with a collection of diseased leaves. She is discussing an example of downy mildew (0176X55–32).

CONSUMED as a health food, popular on the hors d'oeuvre circuit, toast of northern European cuisine, source of the second leading vegetable oil in the world—the protein-rich sunflower seed has an impressive U.S. agricultural potential.

Since 1965 ARS has engaged in an active sunflower breeding program, first at College Station, Tex., and, since 1970, at Fargo, N. Dak., Bushland, Tex., and Davis, Calif. This effort has been aimed at developing hybrid varieties characterized by high yield, disease resistance, and uniformity for economical harvesting.

Also supporting this work is a multidiscipline research team of Yugoslav scientists who are developing hybrid sunflower varieties that are superior to presently grown open-pollinated varieties. The Yugoslavs have obtained breeding lines and germplasm from all over the world, primarily from Romania and the Soviet Union. As a result of the Special Foreign Currency sponsored sunflower program, much of this genetic material is now available to ARS plant breeders.

ARS-cooperating scientist David E. Zimmer (State University Station, 0210 Waldron Hall, NDSU, Fargo, ND 58102) says that the United States has 1.158 million acres of sunflower (*Helianthus annuus*) under cultivation and is the world's foremost exporter of whole sunflower seed and a major sunflower oil exporter. This year, 70 to 80 percent of the U.S. oilseed acreage will be planted to hybrid varieties from parental stock developed by ARS research.

"The potential of this crop," Dr. Zimmer says, "is in its genetic diversity. Because of the ecological adaptability this diversity confers, *H. annuus* may well be grown in the future on the western fringe of the cornbelt from southwest Texas to the Canadian border."

The Yugoslav research is divided into three subunit studies: genetic development and evaluation, correlation between photosynthetic apparatus and yield, and diseases that adversely affect photosynthesis.

The genetic research has involved about 60 percent of the project resources thus far. To obtain vigorous F_1 hybrids the Yugoslavs have utilized cytoplasmic-male sterile (CMS) lines and

restorer or father lines (called RHA for "Restorer Helianthus Annuus").

For example in three way crosses, progeny of CMS x HA inbreds are crossed with RHA inbreds to produce fertile hybrids with genetic dominance for desirable characteristics. In 1975 the Yugoslavs tested 2,000 different sunflower hybrids for yield alone.

Another phase of the Yugoslav program is investigation of sunflower oil quality and quantity, especially the improvement of linoleic acid content in sunflower seed. Linoleic acid is one of the essential fatty acids in vertebrate nutrition.

Photosynthetic studies showed that yield is correlated with leaf area and the chloroplast content per unit of photosynthetic area. A number of variables are involved. Chloroplasts include chlorophyll and carotenoids, green and yellow-to-red pigments, respectively. The variables include number of leaves, leaf size and configuration on stem, amount of chlorophyll present, and how efficiently the products of photosynthesis are transferred into the developing seeds.

Chlorophyll is the pigment that uses solar energy in the process of photosynthesis. The function of carotenoids is not fully known, but there is evidence that these pigments protect chlorophyll from solar destruction and may have other indirect roles in photosynthesis.

The Yugoslav scientists are also concerned with various foliar diseases that reduce photosynthetic effectiveness. Results of their plant pathology work have supplied ARS breeders with promising new sources of resistance to downy mildew, tolerance to leaf and stem spot (caused by *Alternaria* spp.), and resistance to one or more phases of wilt and head rot (caused by *Sclerotinia sclerotiorum*).

This Public Law 480 project is directed by Dr. Tihomir Vrebalov at the Institute of Agricultural Research, Novi Sad, Yugoslavia. Dr. Rodrigo G. Orellana, Beltsville, Md., is the associate ARS-cooperating scientist.—*M.C.G.*

Computer helps fight pests

MATHEMATICAL MODELING—a technique for solving "real life" situations on a computer—is finding more and more application in agricultural research.

The method can save countless hours, days, or even years of sweating in field plots waiting for such developments as crops to mature or for insect populations to multiply throughout a season or seasons, for example. Dollars saved are also incalculable.

A recent example of mathematical modeling coming to the aid of researchers and commercial growers was an insect control problem on Florida chrysanthemum ranges.

There, growers were puzzled as to why they needed as many as 86 insecticide applications a season to hold down the population of young larvae of the beet armyworm. The problem was more perplexing since the ranges were enclosed at the top and sides with fine-mesh nylon screen.

Larvae eat the leaves of the terminal buds of plants and it is the terminals that are harvested and sold. As many as 1 million terminals can be destroyed by the larvae each season.

A computer model of the situation was set up by ARS entomologist George D. Butler, Jr., Western Cotton Research Laboratory (4135 E. Broadway Rd., Phoenix, AZ 85040), using the life history of the beet armyworm, the maximum and minimum temperatures of the area, and light trap records. Data from the computer model—without simulated control measures—produced populations similar to those observed in "real-life" fields in Arizona and Florida.

It was then that the effect of insecticides—from data obtained from Dr. Sidney L. Poe, University of Florida—was superimposed in the model. With those insecticide treatments, the insect populations, could not be made to coincide with the actual insect population on the ranges. However, when migrant moths were added to the model, the range populations were approximated.

Thus with use of the model—and later inspection of the range screens—it was found that eggs from migrant moths placed an unceasing demand on the control program.

Upon inspection, researchers found that the lighted ranges attracted moths which gained entrance through slits for guy wires in the shade cloth.

Suggestions to growers were: (1) modify the screens to prevent moths from entering the ranges, and (2) use an insecticide with a longer residual effect.

Since the spring of 1974, there has not been a serious problem with beet armyworms inside the ranges. Growers apply the first application of chemicals to eradicate the population from the range. Light traps then detect incoming migrants which reestablish the population.—*J.P.D.*

Poisonous Triad

Orange sneezeweed

THOUSANDS of sheep die every year after eating any of three poisonous plants from the same family: western bitterweed, pingue, and orange sneezeweed.

Western bitterweed is most serious on overgrazed sheep ranges in Texas, while pingue causes extensive sheep losses in Colorado, New Mexico, and Arizona. Orange sneezeweed is a major obstacle to sheep raising on high altitude summer ranges in most of the Rocky Mountain states.

All members of the family Compositae, these plants occasionally kill cattle, but are mostly fatal to sheep. Losses to western stockmen amount to several million dollars each year.

Now, a cooperative research effort by members of two ARS research laboratories (Veterinary Toxicology and Entomology Research Laboratory, College Station, TX 77840 and Poisonous Plant Research Laboratory, Logan, UT 84322) and the Florida State University has succeeded in isolating the major toxic constituent of the three plants.

The isolated poison proves to be a sesquiterpene lactone that research scientists G. Wayne Ivie and Donald Witzel of the College Station laboratory call hymenovin.

As early as 1921, another USDA scientist had determined that orange sneezeweed was the cause of an ailment among sheep that ranchers called "spewing sickness," but the poisoning agent had not been pinpointed until now.

Western bitterweed

The isolation of the poison, and the discovery that the same poison is common to western bitterweed, pingue, and orange sneezeweed, makes for a better understanding of the toxic effects of these plants. Essentially, what had been three separate problems has been reduced to one, and, since the poison agent of each plant is the same, any antidote developed for one would be effective for the others.

The three plants are closely related, and one of the things that tipped the researchers off to the possibility that they might contain the same poison was the similarity of the symptoms each produced. These symptoms include abdominal distress, depression of the central nervous system, labored breathing, and the loss of appetite. Hymenovin acts by destroying key enzymes and other body constituents, resulting in sickness and death to the animal. There is also evidence that the poison causes a coagulation deficiency that, while in itself is not the cause of death, leads to internal bleeding and contributes to the animal's general decline.

What can sheepmen do to alleviate the problem? Unfortunately, the three plants are widely distributed and eradication is not now practical. At present, good herding practices are the best way of reducing sheep losses. Sheep herders should use the range uniformly and avoid concentrated patches of the

Pingue

poisonous plants. They should allow the sheep to spread out (open grazing), and they should select bedgrounds with care. The bedgrounds should be used for 1 night only, and herders should not provide sheep with salt near the poisonous plants.

Sheep will choose other forage if it is available, so the range should not be grazed so hard that the sheep are forced to eat the poisonous plants. Also, overgrazing causes the undesirable plants to increase.

When moving the sheep, the herder should choose different routes, as the forages along routes of travel are heavily grazed.

In high mountain pastures infested with orange sneezeweed, timing is very important. Orange sneezeweed remains green and succulent after frost has killed other plants, and herders should be careful not to graze beyond the season. Proper timing is important at the beginning of the season as well, since orange sneezeweed remains green under the snow cover and has a head start on desirable forage. Herders should not bring sheep to the range until all snow has disappeared. Indeed, just a few days at the beginning and end of the summer season can mean the difference between successful grazing and disaster.—*B.D.C.*

Grasses help fight weed

Low-growing competitive grasses, with some help from herbicides, can control the growth of reed canarygrass in western irrigation systems. Such control could reduce the annual cost of keeping these systems open by more than $5 million.

Irrigation is the heart and soul of western agriculture, occupying such a major role in food production that anything affecting the cost of irrigation ultimately affects prices consumers pay for food.

Reed canarygrass (*Phalaris apundinacea*), a perennial which flourishes along banks and drainage ditches, has a highly fibrous root system that crawls out into the water and collects passing silt. The collected silt builds up, reducing the size of the canal or ditch until the flow of water is blocked.

Presently the silt is removed mechanically every 5 to 7 years at a current cost of about $1,800 per mile, or more than $300 per mile per year. There are more than 17,000 miles of irrigation canals and 7,000 miles of drainage ditches in the Pacific Northwest and Intermountain regions.

ARS plant physiologist Richard D. Comes of the Irrigated Agriculture Research & Extension Center (H. Rodgers Hamilton Laboratory, Prosser, WA 99350), has found a much easier and less expensive way of keeping Western irrigation systems open and clear. Dr. Comes' studies show that planting competitive grasses—whose roots do not extend out into the water—along canal banks and drainage ditches, and adding a herbicide, retards the establishment, growth, and spread of reed canarygrass.

The grasses used by Dr. Comes were creeping red fescue and red top. Both grasses do well in the West, spreading quite rapidly throughout irrigation systems, and do not become weeds in croplands. However, neither grass can out-compete canarygrass without some help from herbicides. Dr. Comes is working to minimize the amount of herbicides needed to supplement the competitive grasses. There are no herbicides registered for general use in irrigation systems at this time.

Dr. Comes' technique cuts the cost of removing silt and weed growth from the irrigation systems to about $92 per mile per year. If applied throughout the region, the technique would not only save Western farmers money, but would also indirectly benefit consumers nationwide.—*L.C.Y.*

Laboratory technician Warren Rayford studies copper hydroxide precipitated from industrial waste water. Mr. Rayford made the initial observations that led to the copper recovery process (0676X826–14A).

From Question to Discovery

WHEN a scientist finds an answer, he usually finds another question. Questions sometimes lead to discovery.

When ARS scientists found that a starch compound helps recover metals dissolved in water (AGR. RES., March 1971, p. 3), they also found the question of recovering copper bound strongly by a chelating agent.

Bound copper is used in "electroless," or chemical plating by manufacturers of printed circuit boards. Printed circuits have replaced wires in TV and radio equipment, computers, and electronic instruments. Waters used to rinse the circuit boards contain copper complexed with organic acids, usually identified by abbreviations, EDTA and NTA, instead of the names, ethylenediaminetetraacetic acid and nitrilotriacetic acid.

Chemist Robert E. Wing and technican Warren E. Rayford of the Northern Regional Research Center (1815 N. University St., Peoria, IL 61604), discovered that lime, calcium hydroxide, and other calcium compounds precipitate copper from EDTA-type rinse solutions.

"No economical method was known for decomposing these strong complexes until now," says Dr. Wing. "The rinse solutions had to be segregated from the main process waters."

Dr. Wing estimates the cost of treating a solution containing 50 milligrams of copper-EDTA per liter (mg/l.) at about $0.07 for 1,000 gallons. Copper remaining after the treatment is "usually below the Illinois discharge limit of 0.02 mg/l. and consistently below 0.2 mg/l.," he says.

Before treatment, the rinse waters contain 20 to 50 mg/l. of complexed copper. The complexes are toxic to microorganisms in sewage treatment systems.

A calcium complex, replacing the copper complex in the water, is much less toxic. It is biodegradable.

Stringent pollution-control guides go into effect next year. "Even more stringent guidelines are proposed for 1983," Dr. Wing says. "Furthermore, copper hydroxide from the treatment sludge has value. It can be recycled, possibly by the circuit board manufacturer or by suppliers of the EDTA-type complexes."

The calcium compounds are more efficient and probably would be more economical than the starch compound in recovering copper from EDTA-type complexes. Other complexes, however, are only partially decomposed by lime or calcium hydroxide.

Using insoluble starch xanthate and other starch-based products shows the most promise in the continuing studies for recovering copper bound with some other complexes—tartrates or citrates for example.—*D.H.M.*

AGRISEARCH NOTES

No lasting immunity to BSMV

BARLEY stripe mosaic virus (BSMV) is unlike most plant viruses in that numerous strains are transmitted via the seed. The reason these strains are seedborne may be related to an untypical reaction by BSMV in barley.

Most plant viruses reach a peak concentration soon after infection of a plant, then decrease rapidly. ARS research chemist Myron K. Brakke (Rm. 07, Plant Industry Bldg., University of Nebraska, Lincoln, NE 68503), and plant pathologist Manuel K. Palomar of the University of Nebraska, found that the concentration of BSMV does not follow this pattern.

Instead, BSMV concentration in the two youngest leaves of barley plants was the same at each sampling, regardless of how long the plants had been infected. This result suggests that long-lasting immunity to BSMV does not develop, the scientists say, and may partly explain the seed transmission of this virus.

The temperature at which plants were grown in the study had little effect on virus concentration. At 55°, 62°, 70°, and 77° F, concentration and specific infectivity in the youngest leaves were similar and remained relatively constant throughout the life of the plant.

Shifting plants between 55° and 77° F weekly, biweekly, or monthly did not produce the cyclic pattern of disease symptoms that might be expected if symptom severity at a certain stage of leaf development were dependent on temperature.—*W.W.M.*

Resistance to tobacco budworm

A "WHITE-ROOM" METHOD for large-scale rearing of the tobacco budworm promises to be a significant contribution in the never ending battle to control the ravages of *Heliothis virescens* on cotton.

Eggs from the disease-free stock culture are used by entomologist Maurice J. Lukefahr of the Cotton Insects Research Laboratory (P.O. Box 1033, Brownsville, TX 78520), in evaluation programs to determine the resistance of cotton plants to the tobacco budworm.

The evaluation procedure consists of four separate steps. In the first step a plant extract is obtained from freeze-dried cotton buds by using acetone-ethyl ether. The extract is coated and incorporated into a wheat germ-casein diet. Two-day-old larvae are placed on a diet containing the plant extracts. After feeding for 8 days, the larvae are weighed and growth rates and mortality are recorded. Lines that produce larvae one-half size or smaller than standard are considered resistant.

In the second step of evaluation, lines found to produce larvae one-half size or smaller than standard are evaluated on fresh cotton buds (squares). Two-day-old larvae are placed on detached squares for an 8-day feeding period. Each day a fresh square is placed in the 2 oz plastic rearing container. Lines that produce significantly smaller larvae are considered resistant and ready for the third step in the evaluation procedure.

Cotton plants that are considered resistant are evaluated in replicated cage tests. When plants begin to flower, paired adult tobacco budworms are released into cages. Fruiting patterns of the plants, egg deposition, larvae populations, and rate of larval development are recorded for two consecutive generations.

The final evaluation is the replicated field test. The size of the plot selected is dependent on seed supply and the productivity of the line. Eight-row plots, replicated four times, are necessary for critical evaluation in field tests—the acid test for resistance.—*E.L.*

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AGRISEARCH NOTES

Another serotype of bluetongue

RESEARCHERS have recently discovered yet another serotype of bluetongue virus (BTV), bringing the total to 17 serotypes in the world, four of which occur in the United States.

BTV affects all domestic ruminants (cattle, sheep, and goats) and wild ruminants, including those in zoos. All 17 types of BTV cause identical signs of illness, making identification difficult. Blood samples must be tested in a laboratory before the correct serotype can be identified.

The new serotype was identified by comparing it to the 16 known types maintained by the Veterinary Research Institute near Pretoria, South Africa.

Veterinarian Thomas L. Barber at the Arthropod-borne Animal Disease Laboratory (Denver Federal Center, Bldg. 45, Entrance B, Box 25327, Denver, CO 80225), and Dr. Baltus J. Erasmus of the Institute believe that the BTV probably evolved from an earlier serotype and, much like human influenza virus, differs from year to year.

Serotype 17 was the most prevalent form of BTV in the United States during 1974. So far it has been identified in California, Washington, Idaho, Wyoming, Colorado, New Mexico, Texas, and Florida.

Dr. Barber says, "Because the United States has four serotypes of BTV, we must attack it as if it were four different diseases. The only vaccine now available effectively controls only one of these serotypes."

ARS researchers are now studying the evolution of BTV to gain knowledge which will enable production of an effective vaccine for controlling all four serotypes and epizootic hemorrhagic disease, a different but related disease.—*D.H.S.*

Separating cherries from stems

RESEARCHERS are employing ethylene-releasing chemicals such as ethephon to separate cherries from their stems. This method reduces damage to fruit during storage, packing, and shipping, and may provide a higher quality, more attractive cherry to the consumer.

Stems often deteriorate faster than the fruit. Drying stems pull away from the fruit and cause damage. Stems also restrict storage conditions and interfere with sizing and packaging operations.

The latest test results in a current ARS study show that if ethephon (or similar chemicals) are applied close to harvest time, cherries can be easily separated from their stems during the actual harvest. There is then little damage to the tree, and the damage to the fruit which is associated with stems is reduced.

ARS is conducting this study in cooperation with Washington State University (WSU). Involved in the study are: ARS plant physiologists H. Melvin Couey and Max W. Williams, ARS agricultural engineer Arnold C. Berlage, and WSU horticulturist R. Paul Larsen, all based at Yakima & Mission Sts., Box 99, P.O. Annex 111, Wenatchee, WA 98801.

The ARS–WSU study is applicable anywhere cherries are grown and is aimed primarily at the marketing aspects of a stemless cherry.—*L.C.Y.*

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